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MODEL TEST OF GROUND LAUNCHED ROCKET,(U)

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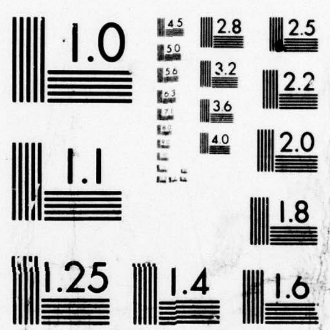

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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

MODEL TEST OF GROUND LAUNCHED ROCKET

by

Mi Che

FOREIGN TECHNOLOGY DIVISION

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By: Mi Che

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Model Test of Ground Launched Rocket

Mi Che

Model flight test of ground launched rocket is a way of obtaining aerodynamic parameters of model components of a flying vehicle and the condition under which shaking occurs, and also a way of measuring temperature distribution of external and internal components of the model. In the following, we will try to introduce some of the working principles as well as the testing situations.

In the process of designing a flying vehicle, people often use tunnel model test to determine the flight performance of the vehicle. But tunnel model test has its own limit. If a ground launched rocket is used to make model test, the model is movong and the testing space is the vast sky, so it is much closer to the real flight situation. This is what a tunnel test cannot accomplish. Moreover, some test will be affected by a certain condition in the tunnel, such as in shaking test, it is easy to break the model and there is even a danger of breaking the tunnel. In order to satisfy the requirements of flying vehicles, the model test of ground launched rocket has developed.

The Principles of Test

As the name indicates, a rocket test is a test that uses a rocket engine as power to let a rocket which carries a model be launched from ground and fly in the sky. When the test is completed, the shell of the rocket can be brought back to the ground by a parachute or let it fall back by itself.

In order to have expected results from the test, the components of the test (such as wing, fin, body and rudder) must first of all have model design. Generally speaking, the model used for rocket testing is larger than that used for tunnel testing, but smaller than the components of a real flying vehicle (the small components, such as loose rudder and loose rear fin, a model can have the same size as the real ones), and the structure is different ,too. So the degree of resemblance with the real components must be determined by flight speed of the rocket, the condition of the atmosphere, and the size of the model. Thus the results of model test can be counted as the property of real components.

Whay size of solid rocket engine should be selected as power? This must be calculated according to the weights of the model and the rocket, the flight speed and altitude, and it would be the best to use a ready made solid rocket engine. If one solid rocket engine cannot produce the required speed, it can be connected with another. Thus the testing rocket becomes a two-staged one.

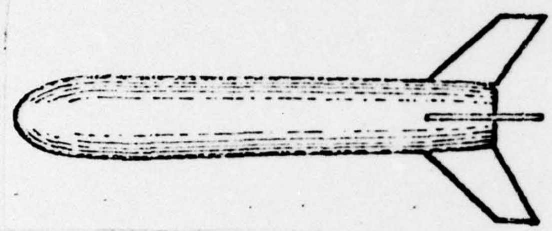
The Contents of Test

The work a ground launched rocket model test can accomplish generally includes the following:

1. Measuring aerodynamic coefficient.

The test can be used to measure the aerodynamic characteristics of the transonic and supersonic speed of a delta wing (such as lifting force). The wing of the model and testing rocket are illustrated by Figure 1; to

measure the impact of a blunt end to the resistance coefficient in a range from Mach number 0.6 to 1.5, and the testing rocket is illustrated by Figure 2; to determine the characteristics (C_L equilibrium, $C_D$equilibrium and Cma) of the lifting force and



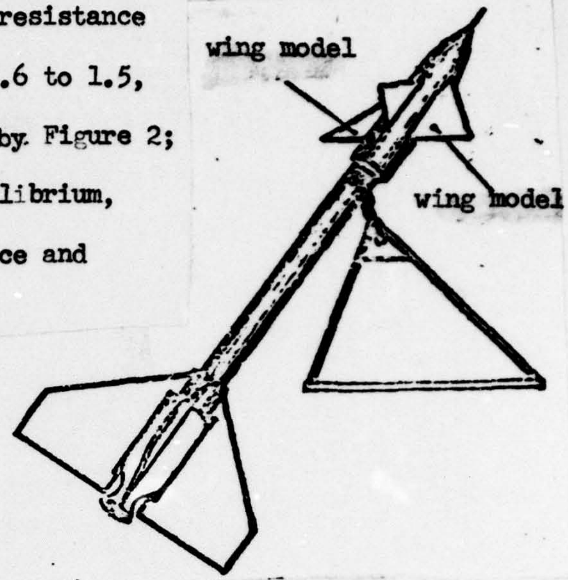
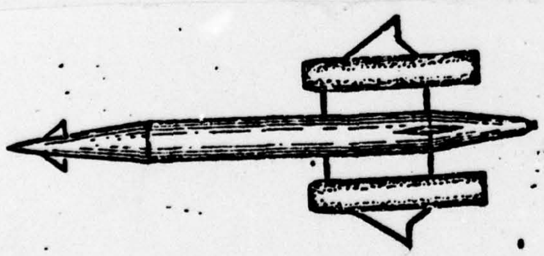


Figure 2

Figure 1

resistance, from Mach number 0.8 to 2.0 , of Duck type missile structure of double-pulsed engine, and the rocket and its thruster are as illustrated in Figure 3; to determine the impact of engine jet (Mach number from 0.8 to 1.2) to form resistance (including thrust, free stream pressure and jet pressure, body pressure coefficient, bottom pressure coefficient and total pressure coefficient), and the testing rocket is as showed in Figure 4.



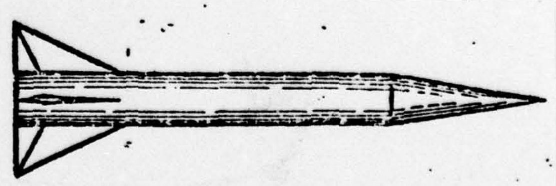


Figure 4

Figure 3

2. Measuring the characteristics of aerodynamic thermal conduction and

instaneous temperature distribution (such as the cover temperature and wing beam temperature), and the testing rocket is as illustrated in Figure 5 (this is only the second stage of the rocket), which is a combination of a two-stage engine. The first stage pushes the model to Mach number 1.6 and the second stage, after ignition, reaches Mach number 2.7.

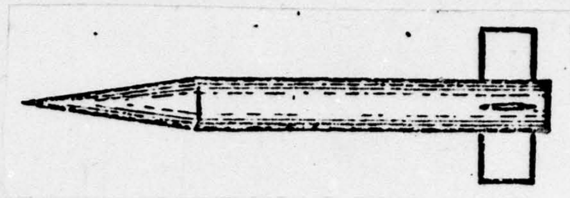


Figure 5

3. Measuring the conditions under which the components of a flying vehicle produce shaking.

4. Observing the trajectory at the thrust stage of a flying vehicle and the condition of separation with the thruster. The model rocket is a miniature of a real flying vehicle in a certain proportion (for instance 1:5).

The Equipment of Test

For facilitating a successful completion of the test, on the ground as well as on the testing model, there must a series of testing equipment.

Equipment on the ground:

1. A specially made high speed camera or akino-theodolite. It is mainly used to trace the flight track of the rocket and to take picture of the flight trajectory of the rocket so that the processes of the test can be analyzed afterward.

2. Doppler radar. It is used to measure the flight speed of the rocket--time curve. The radar is set up at the vicinity of the spot where the rocket

is to be launched. It uses the frequency difference between emitting signal and receiving signal to measure the absolute speed of the rocket away from Doppler radar. For instance, if basic emitting frequency of Doppler radar is 212 mc/s, the frequency difference between emitting signal and receiving signal will be 0-1cm/s, and corresponding flight speed will be 0-708m/s. When the wind speed is subtracted from the speed measured by radar, there is the real speed of the rocket.

3. Receiving station on the ground. After the rocket has been launched from the ground, the receiving station on the ground immediately begins to work. It receives and records the radio signals from the rocket until the completion of the test.

Equipment on the testing model:

1. Transducer. It receives signals from the testing model, and through conducting wire sends them to a transfer unit. Generally a transducer is required to have small size and light weight and it is also required to be able to stand the overload of the rocket in flight.

2. Transfer unit and telemetric emitter. The transfer unit magnifies the signals which come from transducer (if the signals are mechanical ones, they must be transformed into electric ones and then magnified), and by way of telemetric emitter through antenna sends the signals to the ground receiving station. According to the amount of measuring parameter, it can select several, several tens and even hundred of telemetric emitters of large capacity.

3. Electricity source. It supplies energy that is needed by the

equipment on the testing model to maintain working.

Now we would like to make a brief introduction of using ground launched rocket to make shaking test.

In the test, the shaking wing model is set on a rocket shell (Figure6), after the rocket being launched from the ground, the shake transducer at

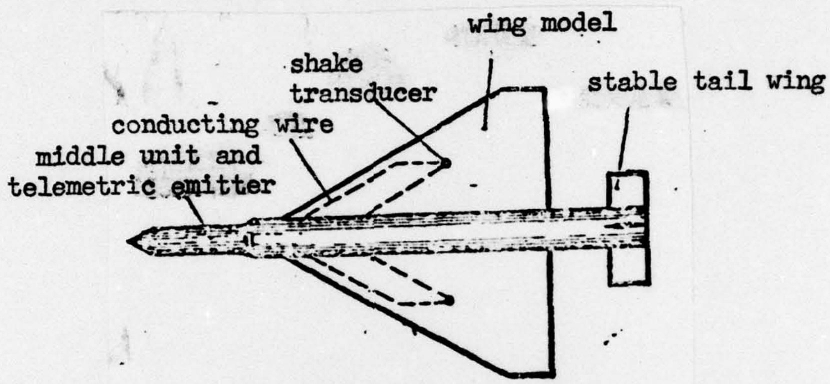


Figure 6

the wing model will transmit the shake signal on the wing model to the transfer unit, which then transforms the shake signal into electric singal and through the telemetric emitter sends the signal to the ground receiving station, and the receiving station will use continuous photography to record the shake singal. The flight of the rocket can be tracked by using high speed camera and the speed can be mearsured by Doppler radar. Once shake takes place, the wing model will soon break. The shake frequency can be calculated based on the wave curve recorded by using continuous photography on the ground receiving station, and the critical speed of the shake can be measured by Doppler radar.

Figure 7 is a shake testing rocket of back-swept wing. The two level

tail wings among the four tail wings are shake model wings, and the two verticla wings are used to maintain direction stability. The rocket can be launched from a launcher, which has an angle of 60°. In order to determine the speed of the model breaking, at each shake model wing there is simple return circuit made of conducting wire, which is connected with the electricity sourse of the telemetric unit set at the head of the rocket. When a model wing is broken, the signal will immediately becomes a zero, and the breaking speed of the model can thereby be calculated.

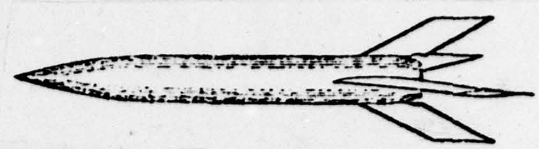


Figure 7

This is all about the model test of ground launched rocket. Such a test has made significant contributions to the development of aerodynamics as well as some special problems in flying vehicle design. There are some kinds of results which cannot be obtained by theoretical calculation, and tunnel test has its own limitations, so the model test of ground launched rocket is the only way which has proved so useful.

Nevertheless, there are some problems in the model test of ground launched rocket. For instance, after the rocket being launched, poeple who are working in the test cannot control the rocket any more. In order to have the expected results from the test, situations and problems should all be known well and prepared well. Relatively speaking, the times of rocket test cannot be very many (compared with tunnel test), and the testing model is smaller than real components (compared with ground rocket vehicle test). These problems may be solved if they are combined together with tunnel test and ground rocket vehicle test.

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